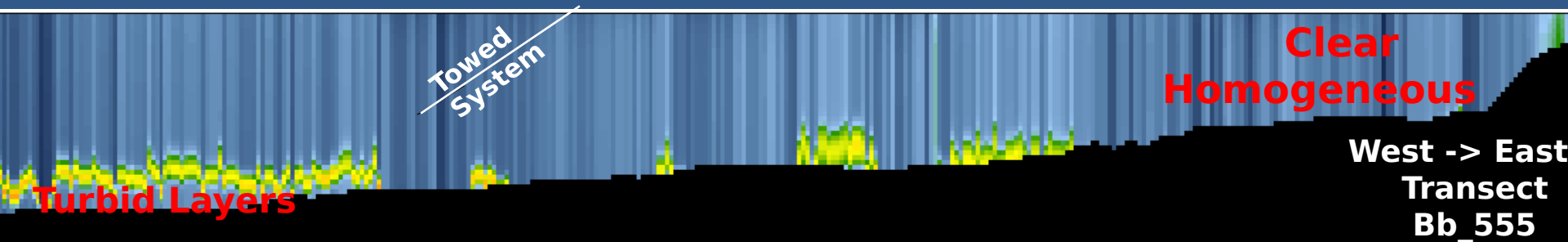




Forecasting the Ocean Optical Environment for EO Performance Surfaces

**New capability to support the HM Squadron's
ASQ 24 and diver operations using
Gliders , Models and Remote Sensing**



Sherwin Ladner, Robert Arnone
Ocean Processes Branch
Naval Research Laboratory

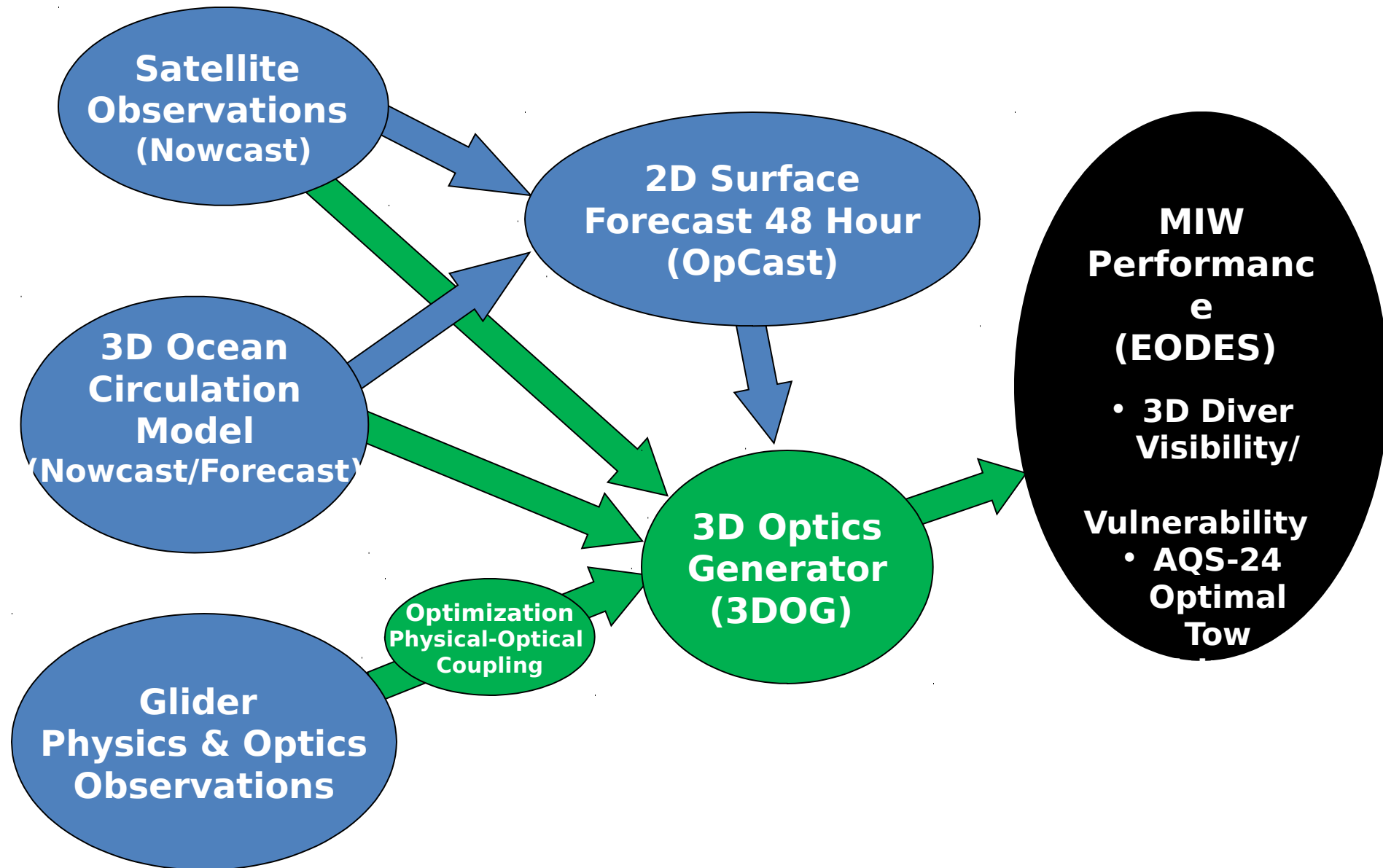


Tactical Ocean Data System (TODS) Components



- **LAGER** - Quality control of glider optical and physical properties
 - Deployment, Processing and data QC and analysis
- **OPCAST** - 2D Forecasting of Surface Optics out to 48 hours
 - Coupling Satellite optics and models
- **3DOG** - 3D Optical Volume Generator
 - Fusion of Gliders, Satellites and Models
- **Performance Surfaces** (EODES Model, Diver Visibility)
 - Linking the 3D optics with the AQS 24

Tactical Ocean Data System (TODS)



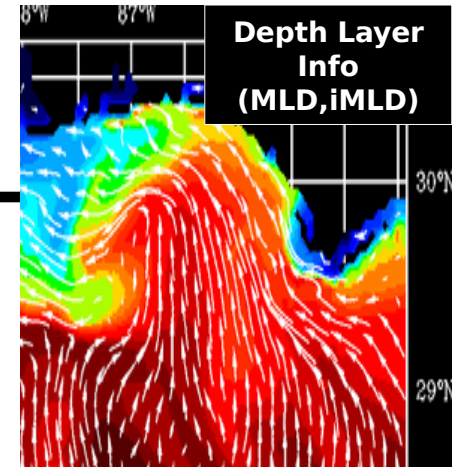
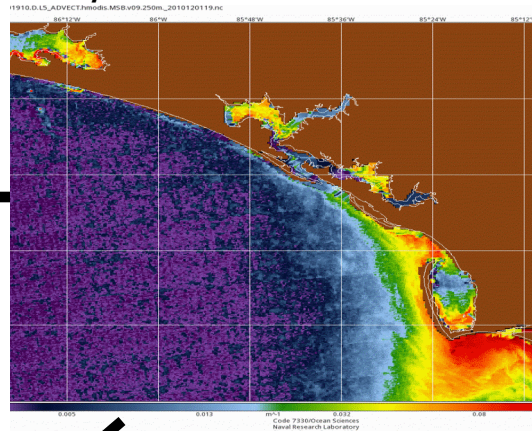
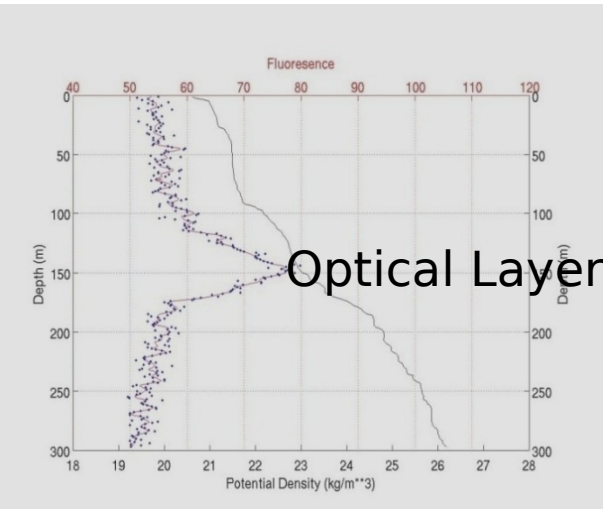


Integration of Glider Profiles, Satellite and Numerical Models to support AQS24 Operations

Vertical Optical Profiles
(Glider, BSP, etc.)

Nowcast / Forecast Satellite Optics

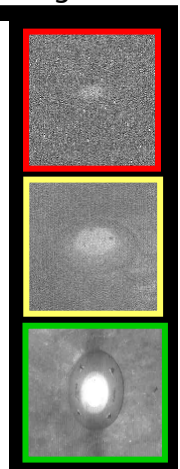
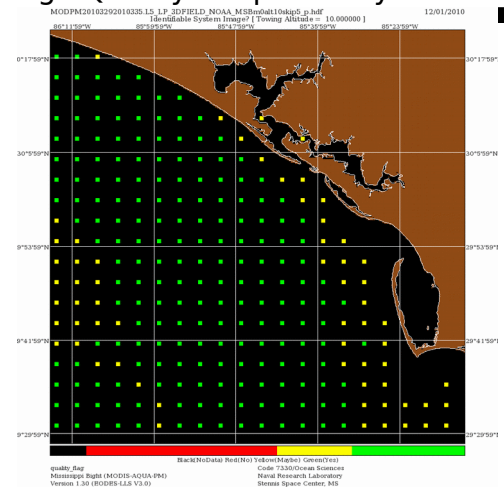
Nowcast / Forecast
Circulation Models



What Happens
Below
Satellite Surface
Today and
Tomorrow?

EODES

Nowcast/Forecast Performance Surface
Image Quality & Optimal System Towing Altitude



3D Optical Volume & Diver Visibility



TODS Fleet Demonstration and Support Of EO Laser Imaging Performance

Support provided to HM-14 HARP Exercise

VULCANEX 11-1 - Panama City, FL - March 30, 2011 - April 08, 2011

TODS Support (Daily Brief Provided to Fleet):

- a) Nowcast/Forecast (24,48 hours) of the Optical Environment (2D & 3D) ☑ Impact on laser system (ASQ 24) and diver visibility
- b) Nowcast/Forecast (24,48 Hours) 3D Optical Volume / Vertical Optical Layer
- c) Nowcast/Forecast (24,48 Hours) Eoids/AQS-24, ALMDS and diver performance surfaces
- d) Circulation models ☑ 3Km NCOM-RELO
- e) Optical profiles collected in real-time using Slocum glider for assimilation into 3D Optical Volume (Tuning Coefficients defining the optics to physics relationship)
- f) End-to-end testing and evaluation of TODS system components (OpCast, 3DOG <- glider optics profiles, performance surfaces <- AQS-24 snip)

Vulcanex 11-1 HARP Exercise Planning

HARP Objectives (AWSTS):

1. Assess the HM squadron's operational capability / level of AMCM combat proficiency
2. Assist in identifying potential problem areas in mission capability.
3. Assist in the tactical training of personnel to increase mission readiness.

Mark J. Reynolds

Technical Systems Integration, Inc. Oceanographer/Test and Evaluation

AMCM Tactics Support & Training Division Coordination

AMCM Weapon Systems Training School NSWC PCD

Kevin Oakes

Project Manager Op-Area Coordinator (Glider Activity)

AMCM Tactics Development Naval Support Activity

NSWC PCD, Code X32 (Tactics Branch) NSA PCD, N36

Beth Branham

Oceanographer/Test and Evaluation

Division Coordination

NSWC PCD

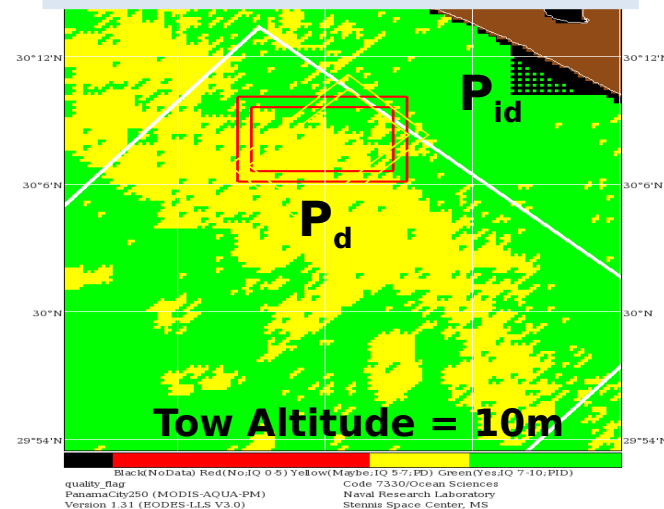
Jeffrey Willows

Op-Area Coordinator (Glider Activity)

Naval Support Activity

NSA PCD, N36

Eoid Performance Surface

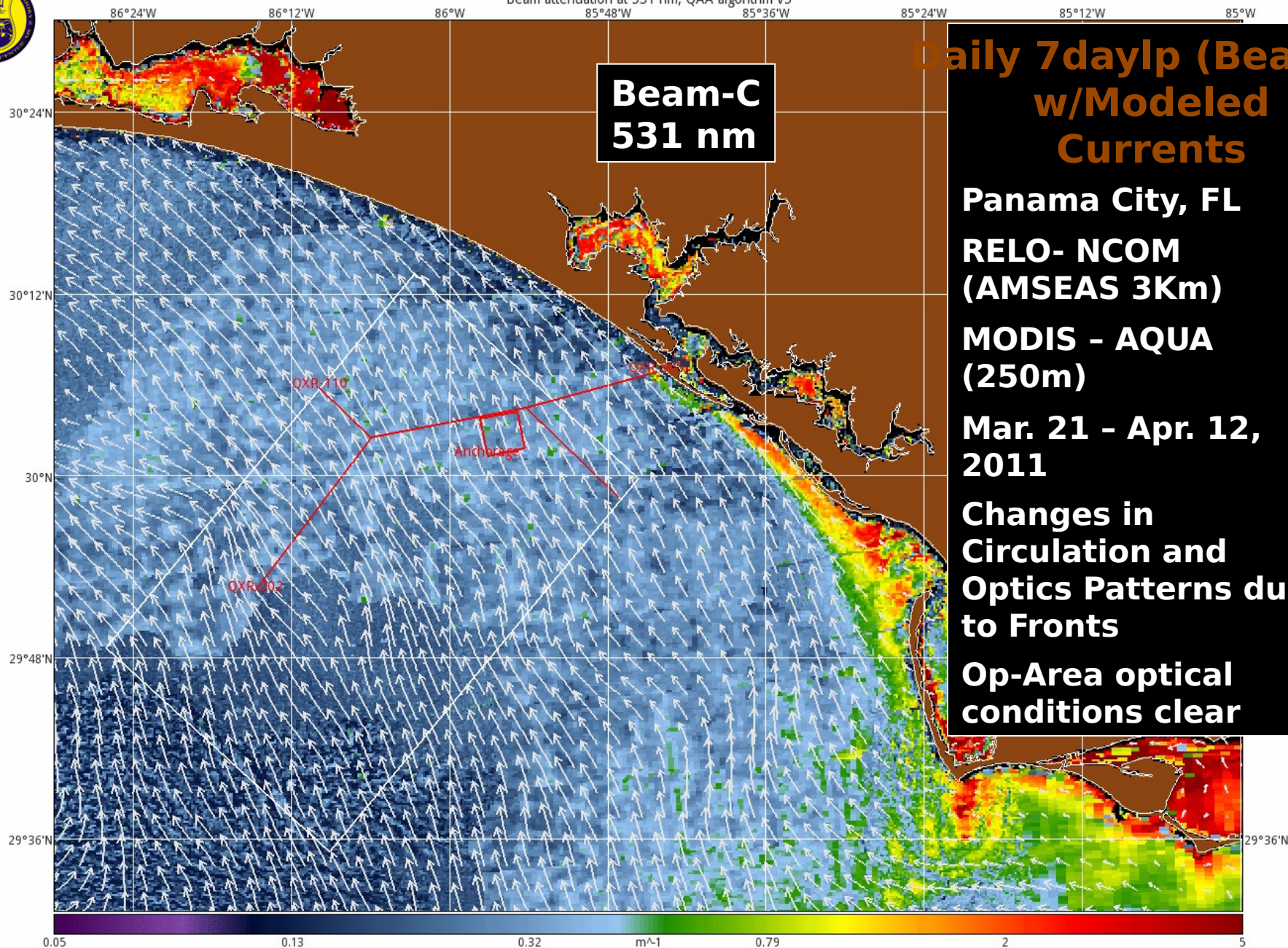




aqua.2011074.0315.2011080.0321.D.L4_LP.hmodis.PAN.v09.250m.hdf

Beam attenuation at 531 nm, QAA algorithm v5

Mar 15-Mar 21, 2011 (1LP)



**Beam-C
531 nm**

**Daily 7daylp (Beam-
w/Modeled
Currents**

**Panama City, FL
RELO- NCOM
(AMSEAS 3Km)**

**MODIS - AQUA
(250m)**

**Mar. 21 - Apr. 12,
2011**

**Changes in
Circulation and
Optics Patterns due
to Fronts**

**Op-Area optical
conditions clear**

Clear

Version 9

IS-AQUA-PM)
ects/relo/amseas/ncom_relo_amseas_2011032100_t018.nc, timestep 0

Code 7330/Ocean Sciences
Naval Research Laboratory
Stennis Space Center, MS

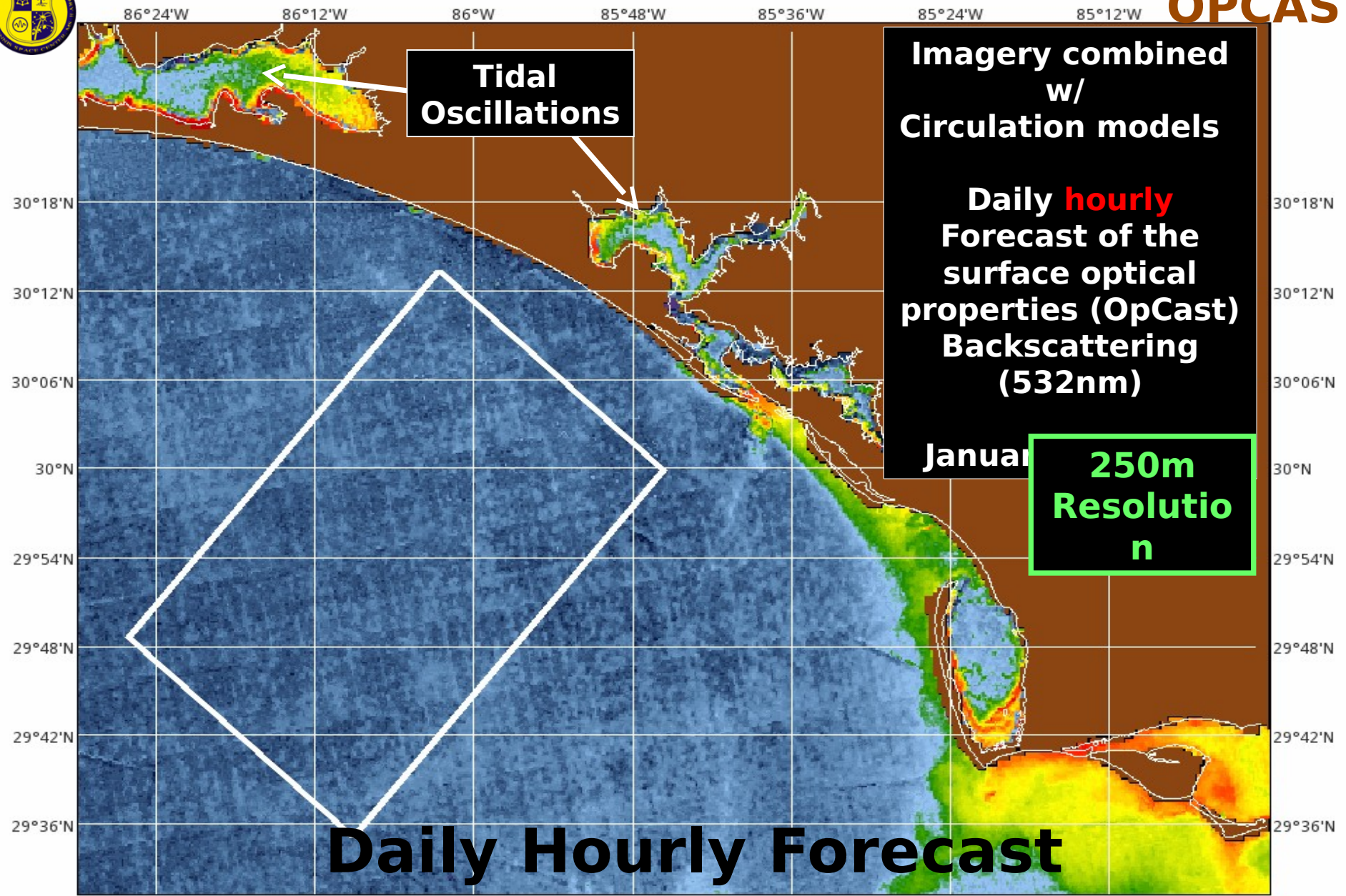
Turbid





aqua.2011015.0115.184916.D.L5_ADVECT.hmodis.PAN.v08.250m._20110115.18.nc

OPCAST



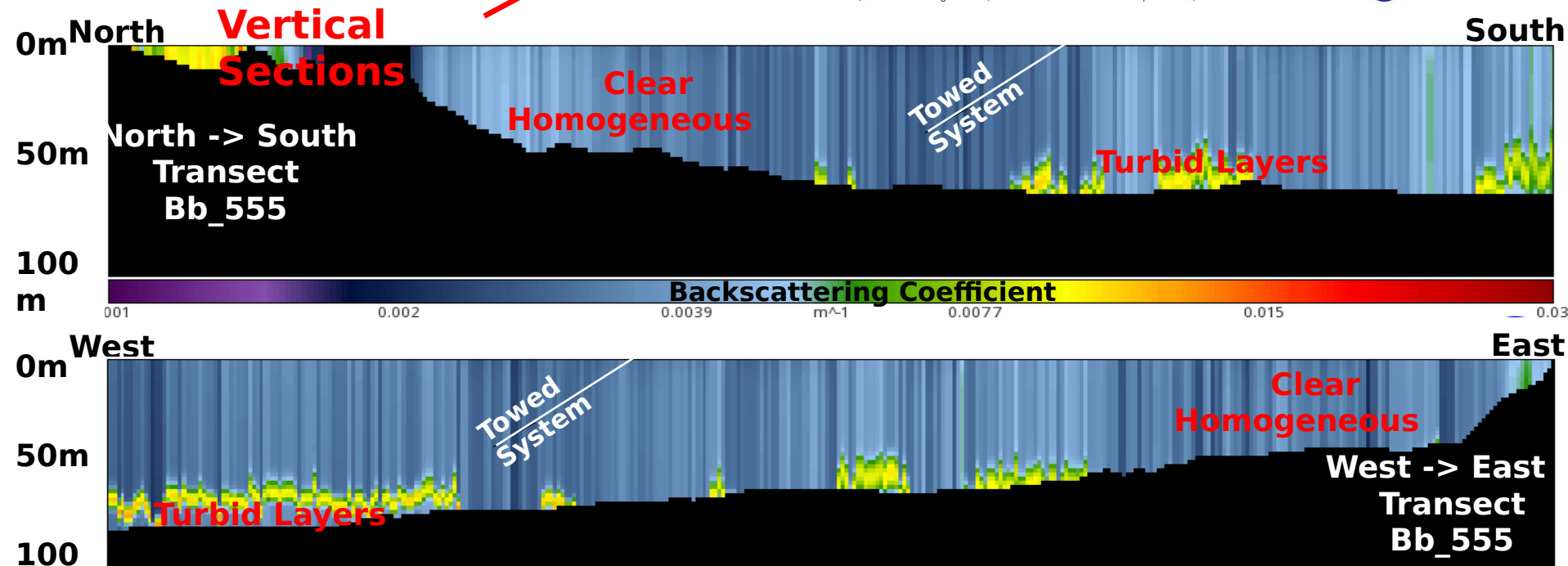
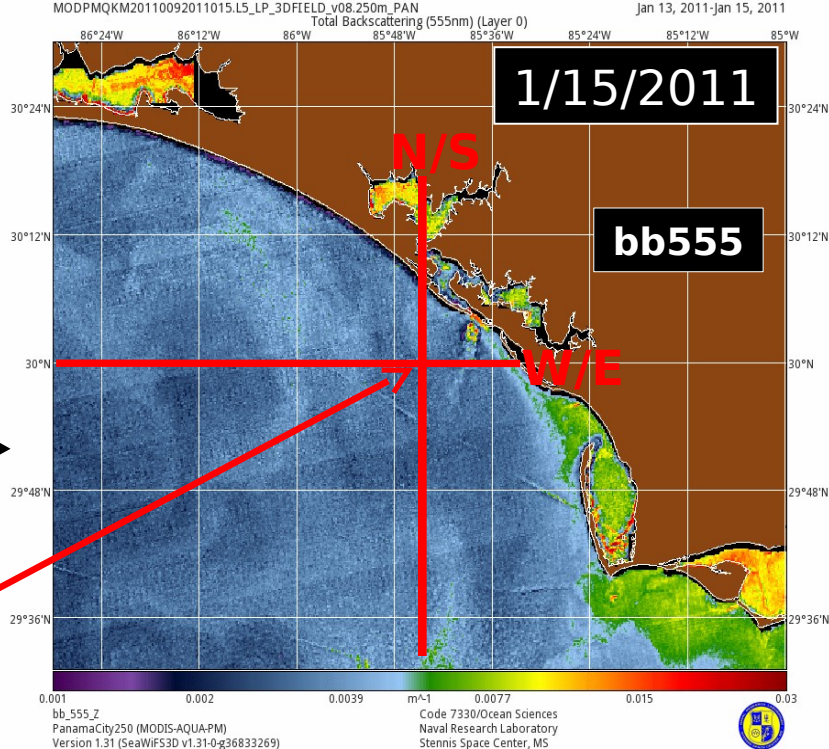


3DOG

3D Optical Generator
Merging
“Satellite, models
and
Insitu data “
Surface to Bottom
Animation
(Black Areas are Bottom)

250m
Resolution
Coefficients

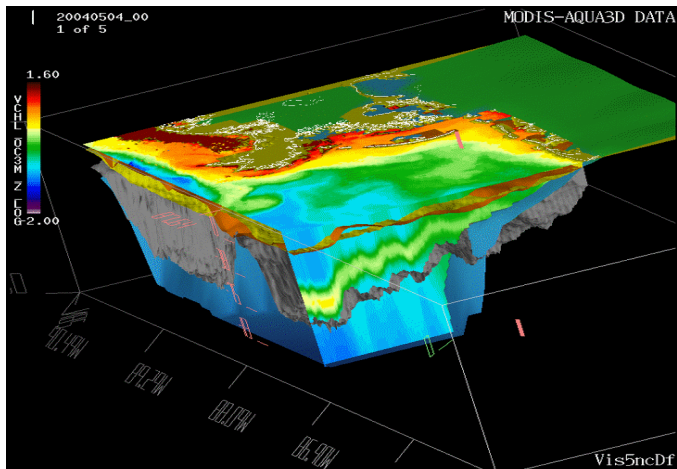
Need
Tuning
Daily
Using
Slider



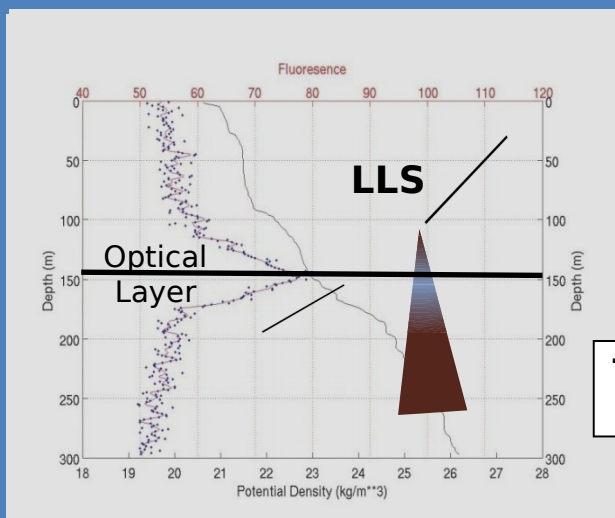
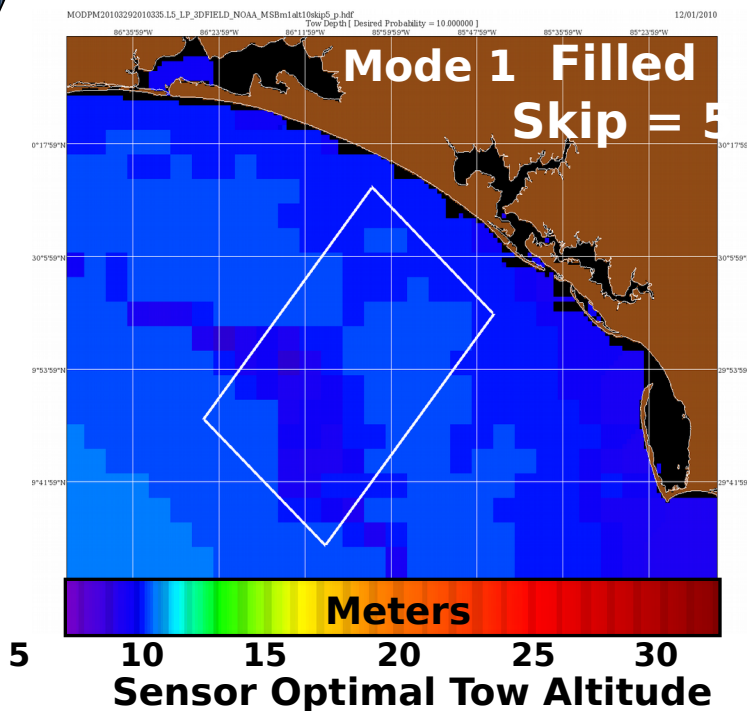
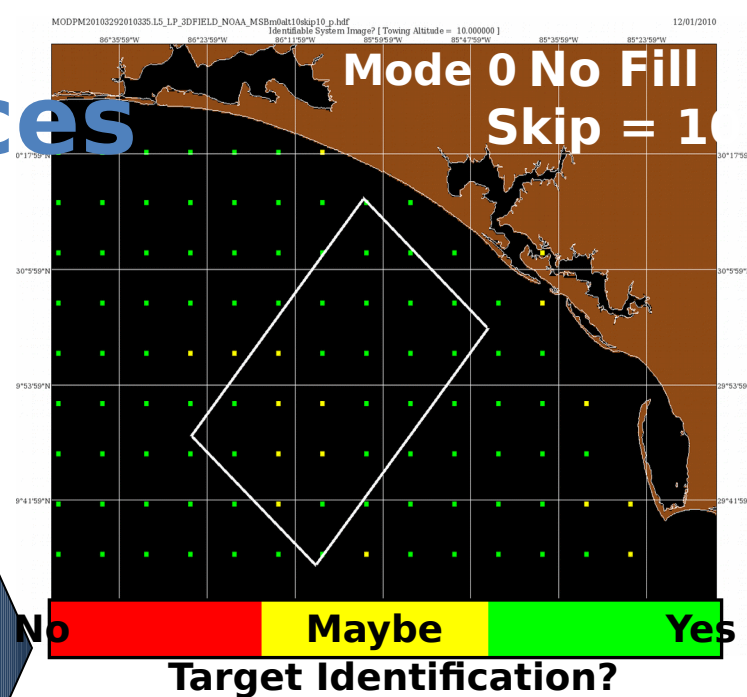


Performance Surfaces

Regional Battlespace Characterization 3d optical profiles



Regional laser
imaging
performance
(EODES Model)

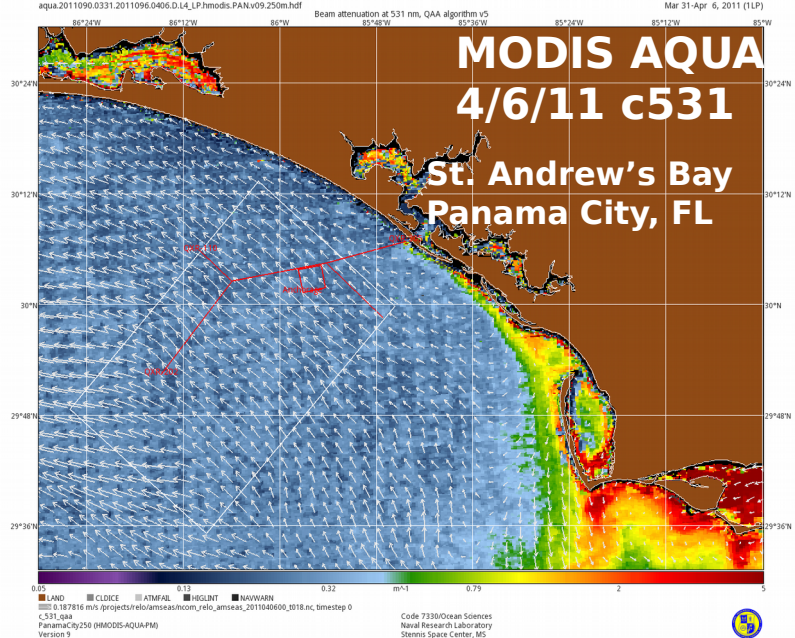


EODES
Point
Performance
(BSP)

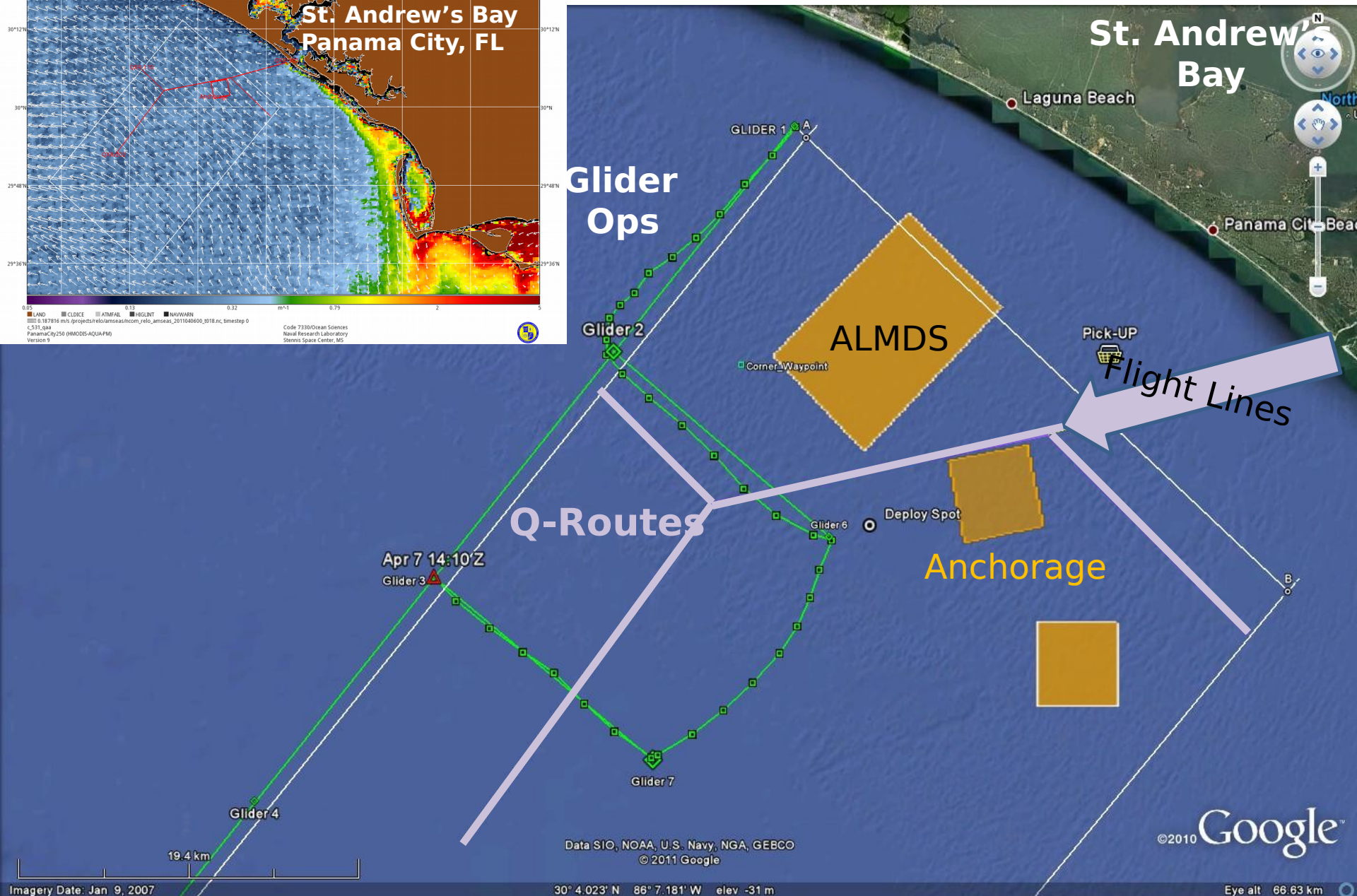
Tow **Above/Below**
Optical Layer

Target ID?





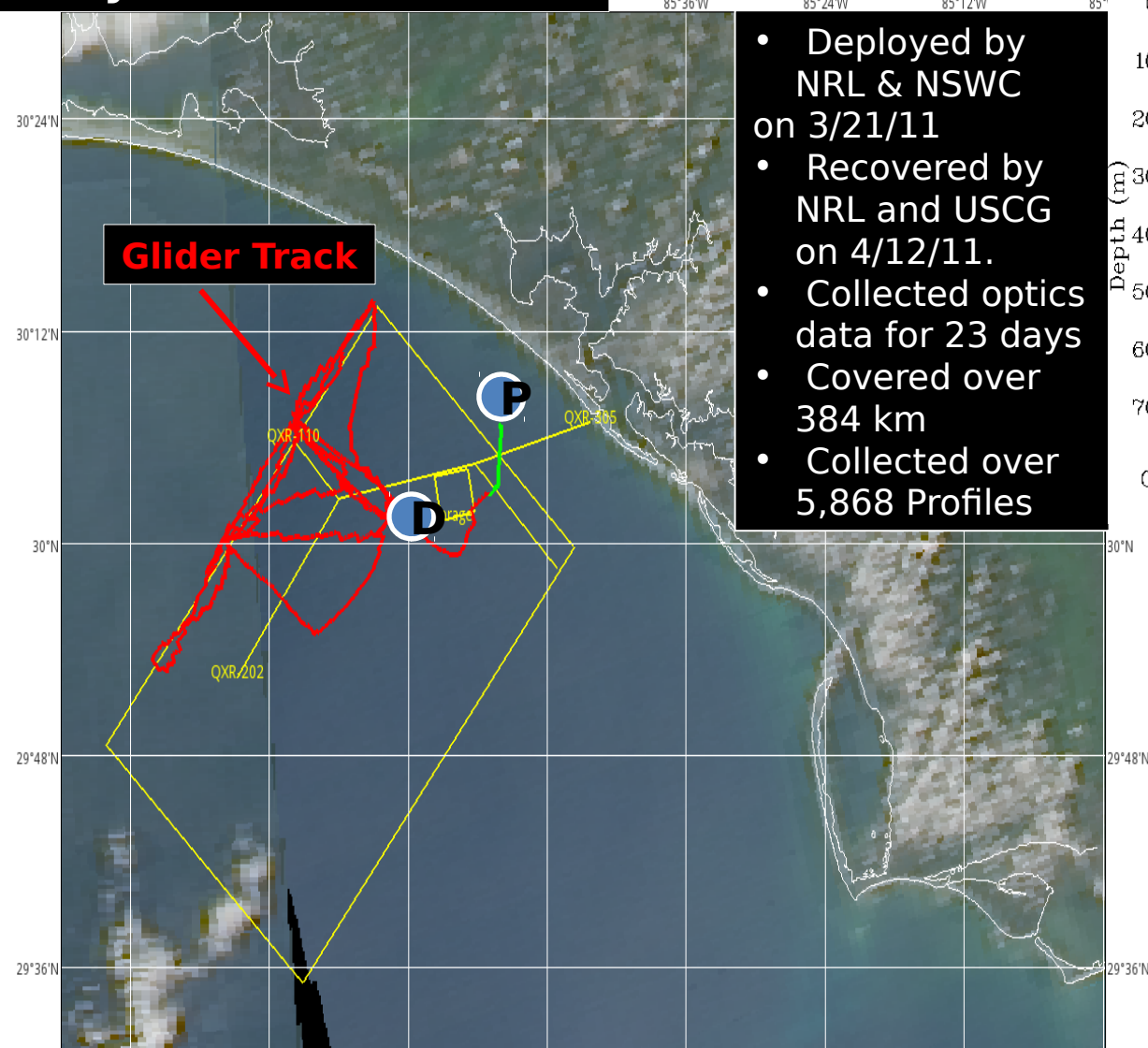
Operational Area



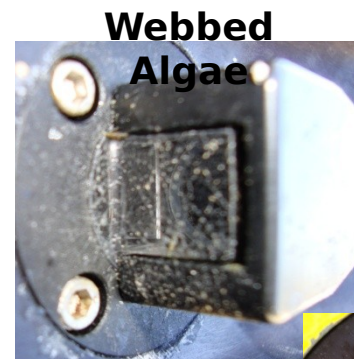
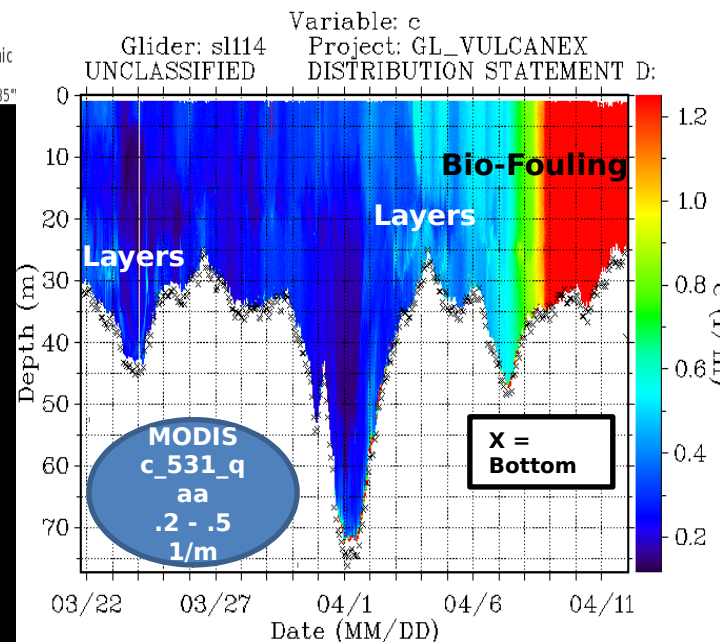


Vulcanex Glider Operations

Daily MODIS True Color



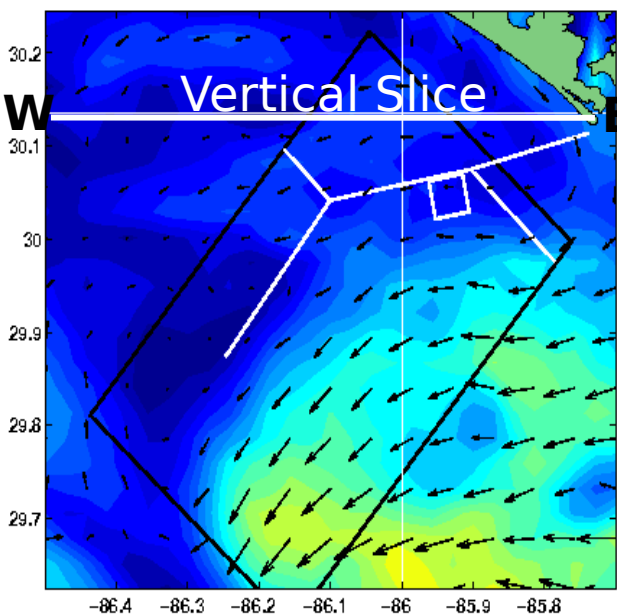
- Deployed by NRL & NSWC on 3/21/11
- Recovered by NRL and USCG on 4/12/11.
- Collected optics data for 23 days
- Covered over 384 km
- Collected over 5,868 Profiles



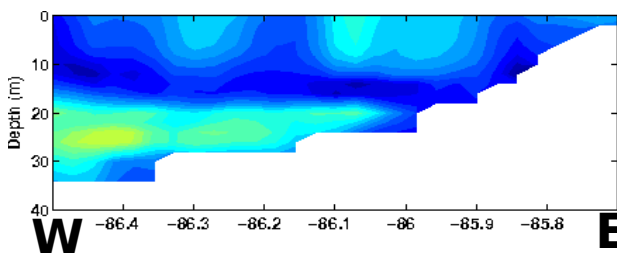


Physical Model Nowcast & Forecast – April 06, 2011

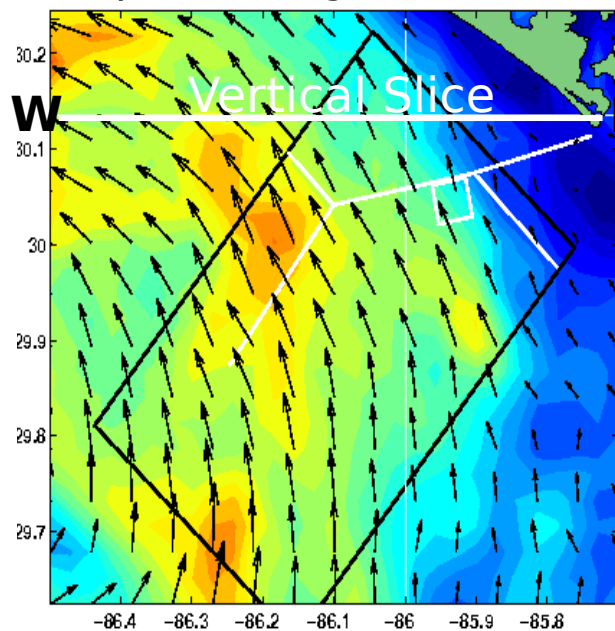
April 06, 2011 00Z
Depth Averaged Currents



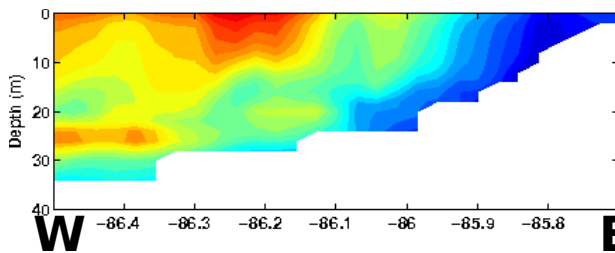
Vertical Slice Velocity @ 30.14N



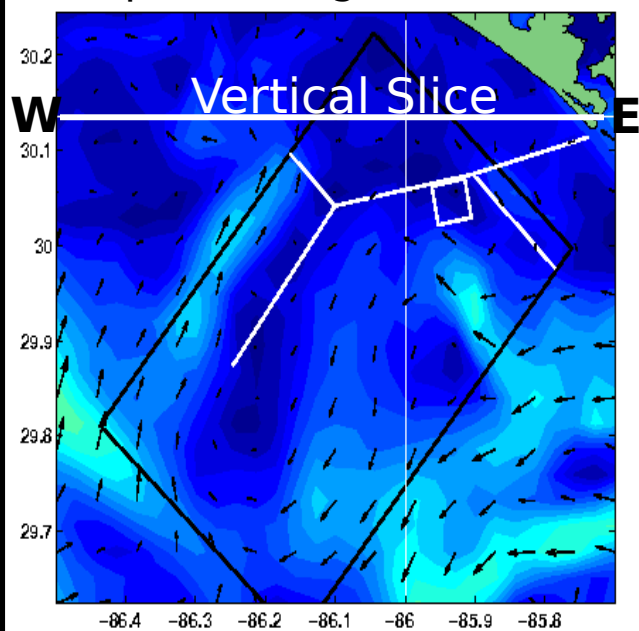
April 07, 2011 00Z
Depth Averaged Currents



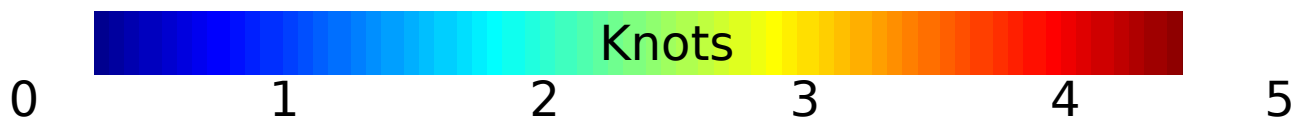
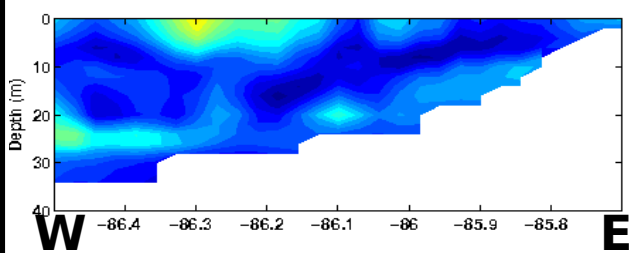
Vertical Slice Velocity @ 30.14N



April 08, 2011 00Z
Depth Averaged Currents



Vertical Slice Velocity @ 30.14N

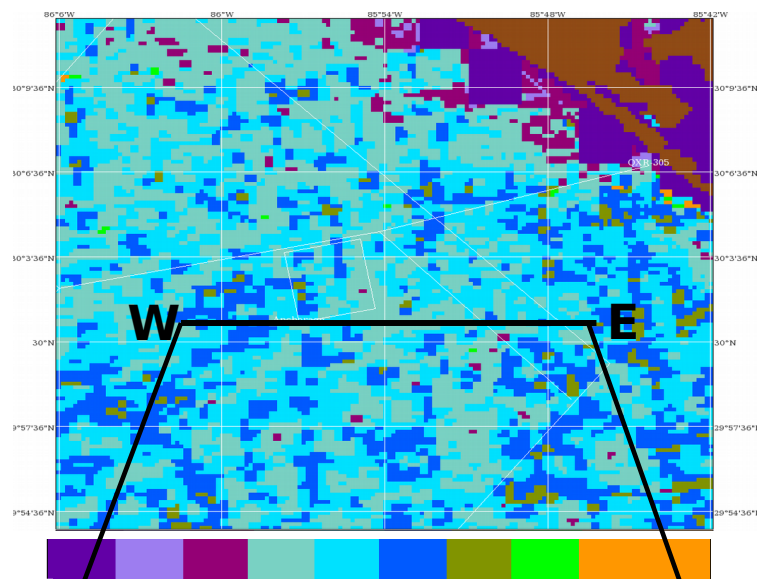




24 Exercise Support Products (Nowcast, 24 & 48 Hour Forecast)

Surface Beam-c / Diver Visibility

4/06/11 19Z



c 531nm
m
Diver Vis
(West->East)

0m
16m
32m

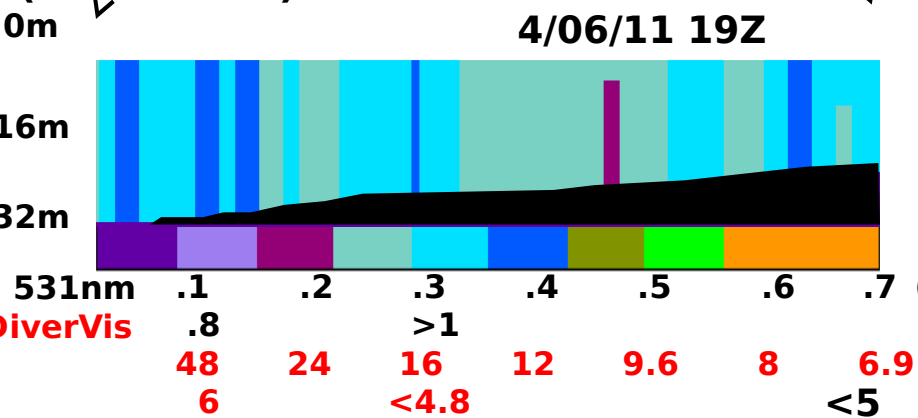
4/06/11 19Z

3D Beam-c / Diver Visibility Slice

0.1 0.2 0.3 0.4 0.5 0.6 (1/meters) meters

0.8 48 24 16 12 9.6 8 6.9

<4.8

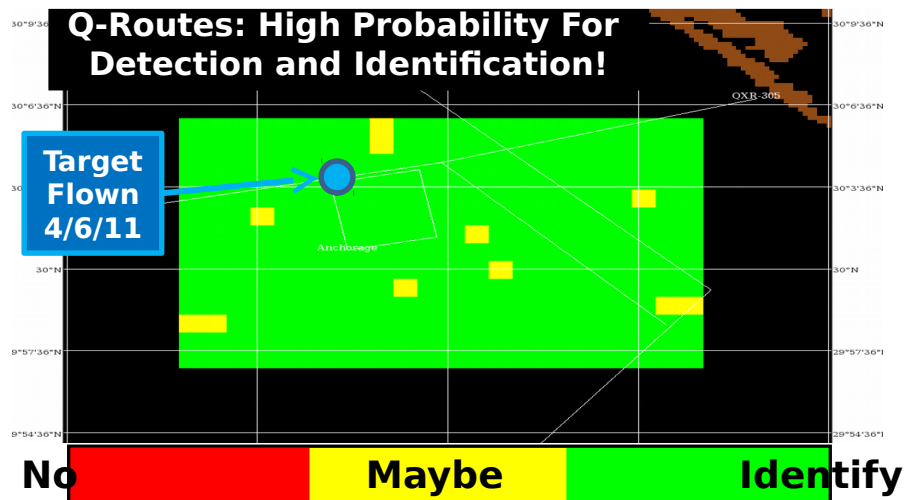


Target Identification @ 6m/19.7ft Tow Altitude

4/06/11 19Z

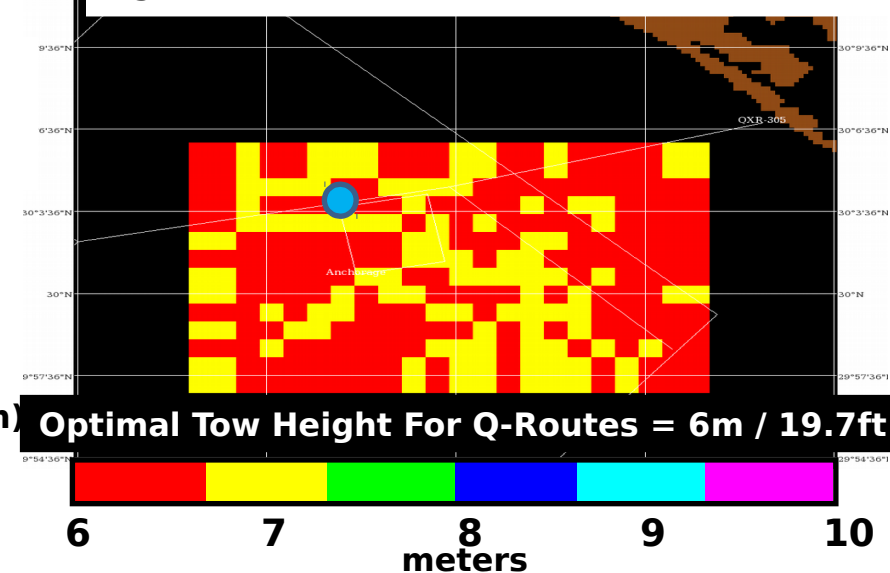
Q-Routes: High Probability For Detection and Identification!

Target Flown 4/6/11



Optimal Tow Altitude - 4/06/11

19Z





24 Exercise Support Products (Nowcast, 24 & 48 Hour Forecast)

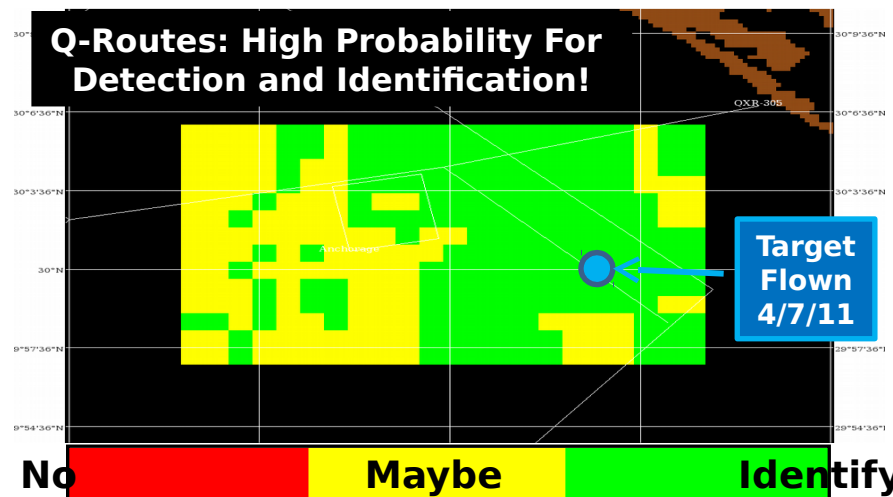
Surface Beam-c / Diver Visibility

4/07/11 19Z

Target Identification @ 7m/22.96ft Tow Altitude

4/07/11 19Z

Q-Routes: High Probability For Detection and Identification!



531nm
m
Diver Vis
(West->East)

3D Beam-c / Diver Visibility Slice

4/07/11 19Z

0m
16m
32m

531nm
DiverVis

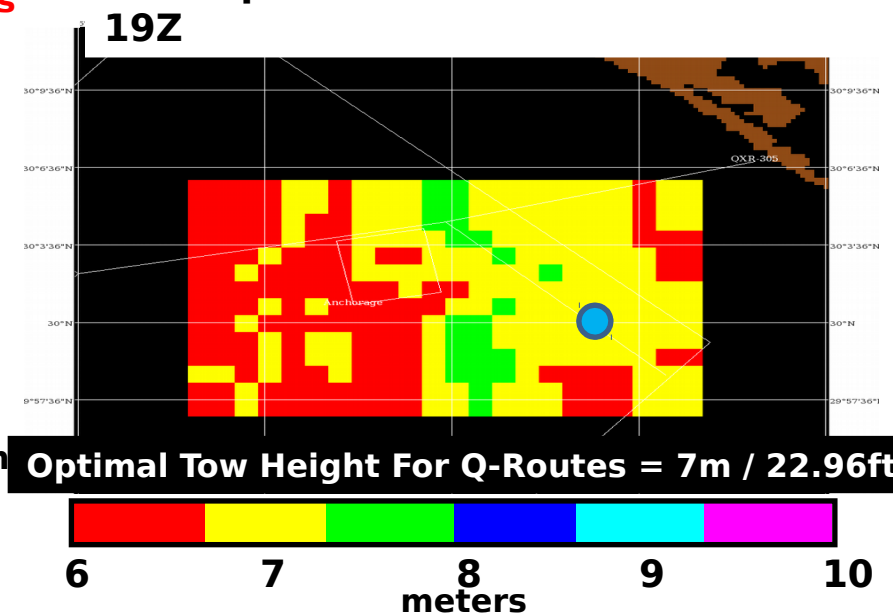
0.1 0.2 0.3 0.4 0.5 0.6 (1/meters) meters

0.8 48 24 16 12 9.6 8 6.9

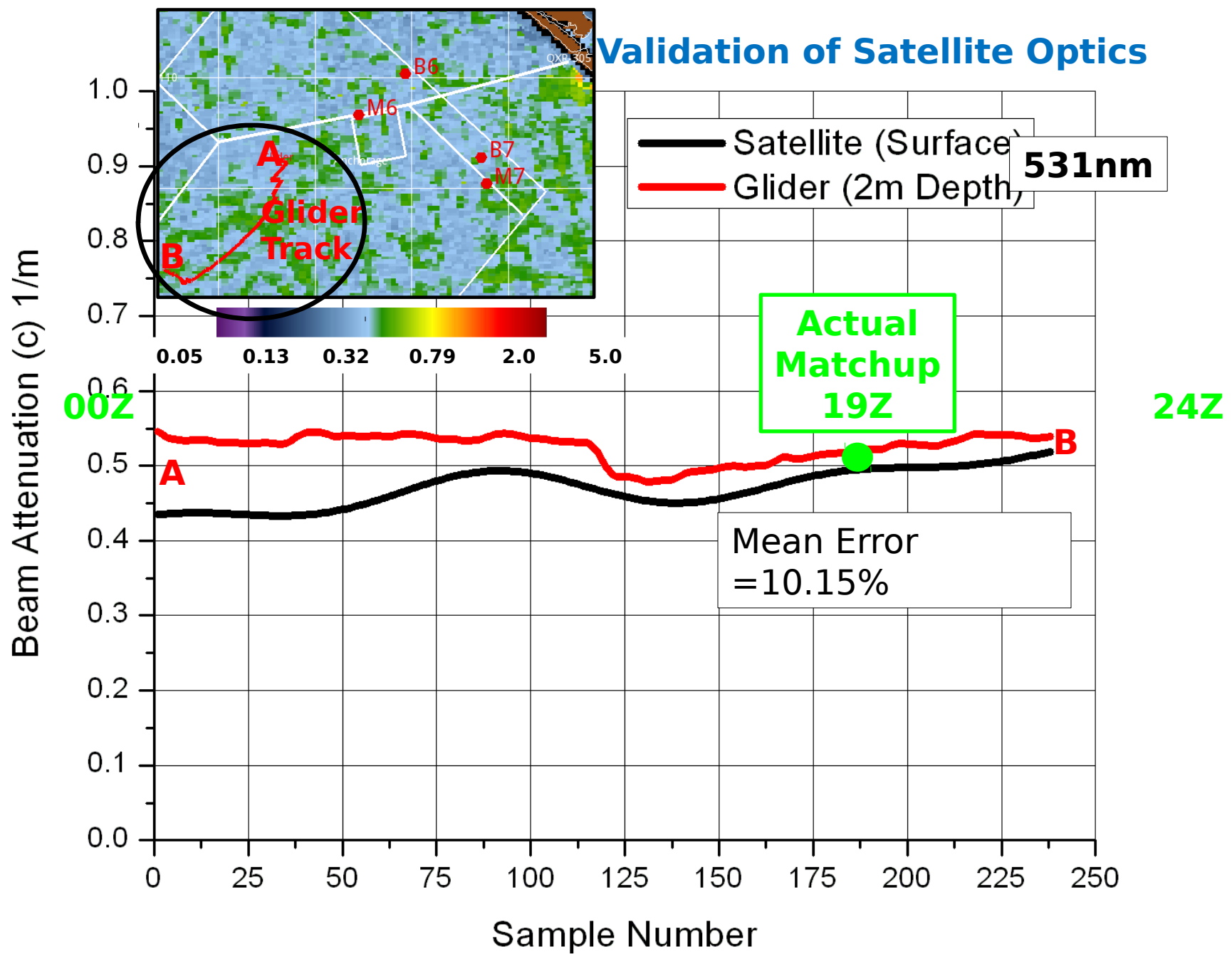
>1 <4.8

Optimal Tow Altitude - 4/07/11

19Z



Validation of Satellite Optics



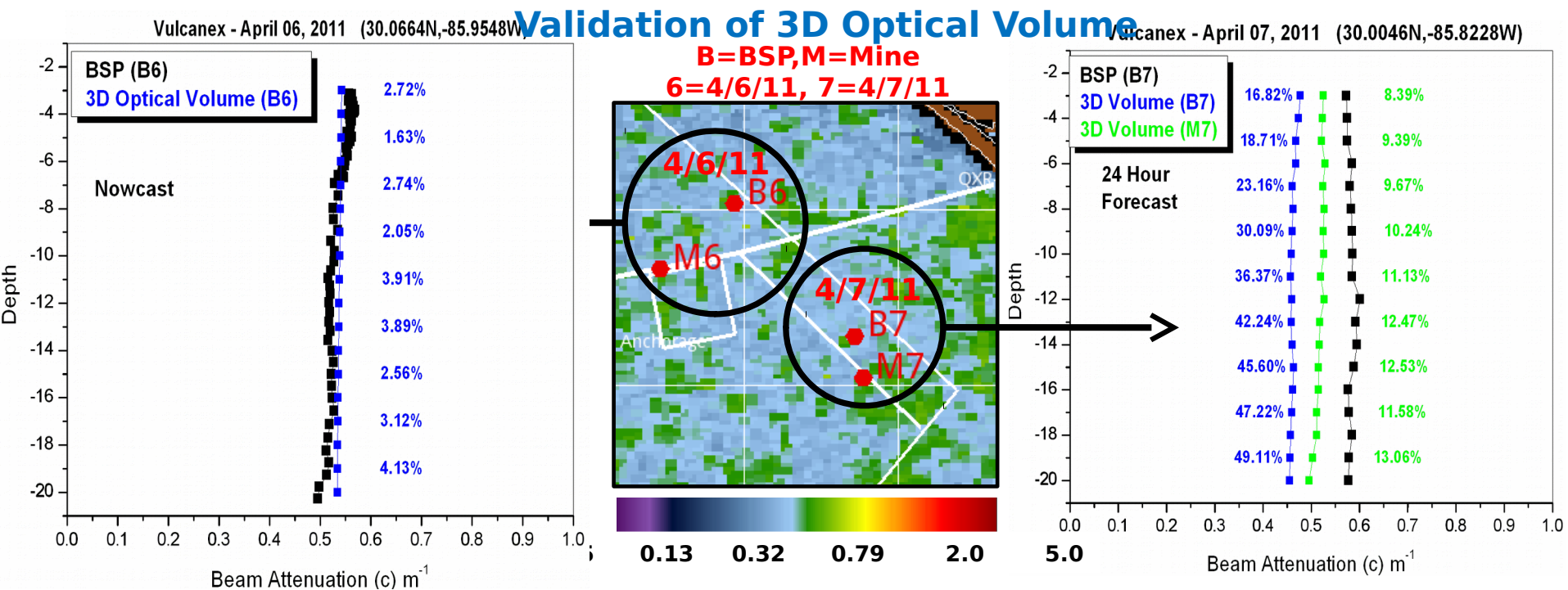
100% of AQS-24 HM-14 System Performance Validation - VULCANEX 1 Mine Targets At Suggested Tow Altitudes Identified!

Same Target

STEP 3 UPS

STEP 6 UPS

Actual (HM) and Suggested (NRL,NAVO) Tow Heights										
#	Date	GMT	Mine Type	HM-14	NRL	NAVO	DET	ID		
1	4/6	2132	Mk52	20.0 ft	19.7 ft	19.7 ft	YES	YES		
2	4/7	2238	Mk52	24.0 ft	22.9 ft	19.7 ft	YES	YES		
3	4/7	2256	Mk52	20.0 ft	"	"	YES	YES		
4	4/7	2310	Mk52	17.0 ft	"	"	YES	YES		
5	4/7	2043	Mk52	17.0 ft	"	"	YES	YES		
6	4/7	2050	Mk52	20.0 ft	"	"	YES	YES		
7	4/7	2106	Mk52	24.0 ft	"	"	YES	YES		



Vulcanex AQS-24 System Performance Surface Validation

Apr 06, 2011 (Nowcast)



ST A	IQR	ID ?	OTA	SNIPPET
7m 22.96ft 4/6/11				
Legends		<p>Yes Maybe No</p>	<p>(m) 20 23 26 29 32 35 (ft)</p>	<p>Note: Loss of Contrast, Size and Detail</p>

Vulcanex AQS-24 System Performance Surface Validation

Apr 07, 2011 (24-Hour Forecast) - Step Ups

	IQR	ID?	OTA	SNIPPET
5m 16.7ft 4/7/11				
6m 19.7ft 4/7/11				
7m 22.96ft 4/7/11				
Legends		Yes (IQR 7-10) Maybe (IQR 5-7) No (IQR 1-5)		Note: Loss of Contrast, Size and Detail

Summary

HM-HARP Vulcanex 11-1 Fleet Demonstration & Product Validation

Panama City, FL (March 30 - April 08, 2011)

- First time an ocean optical forecast provided to MCM operations
- Demonstrated Nowcast/Forecast capabilities of Tactical Ocean Data System (TODS) - AQS-24 Performance Surfaces
- Provided daily optics brief of the environment (Nowcast/Forecast) to HM-14
- 100% of Mine Targets at suggested tow altitudes identified!
- Obtained validation data for MCM performance surfaces (Glider, BSP, Snippets)
- Fleet Feedback:
 - Products were *crucial* to the overall assessment of the squadron's capabilities
 - Predicted optimal tow heights provided a baseline to brief pilots and air crewman prior to their missions
 - Correlation to post-mission BSP resulted in similar water column assessment
 - Products were user friendly and provided useful and reliable information for mission

Summary (Continued)

Impact on Warfighter:

- Option to input user defined tow height (better image quality -> IQR)
- Predicted/forecasted tow heights provide more efficient mine clearance planning and timeline with same probability of identification
- Increase in probability of detection/identification using tow heights based on predicted/forecasted optical 3D environment.
- Helps UMCM dive units with re-acquisition and ID missions by providing a predicted 3D diver visibility performance surface.
- Forecasts of subsurface current velocities and direction provides important mission planning information for:
• sweeping mined mines

Support Slides

nding:

R&D: \$75K (Software Enhancements, R&D)

RL Glider Ops (3 -1 week Deployments): \$150K (2 - VACAPES Annual + Bold Alligator)

1 Week Deployment (1 Person):

Ship: \$5K

Travel: \$10K

Prep: \$10K

Batteries/Comms: \$10K

Boat: \$10K

Cals: \$5K

Total: \$50K

Operational TODS: \$150K

VACAPES(Annual Support Start Jan 2012)

TACDEVEX(Arabian Gulf Nov. 2011)

BOLD ALLIGATOR (VACAPES Feb. 2012)

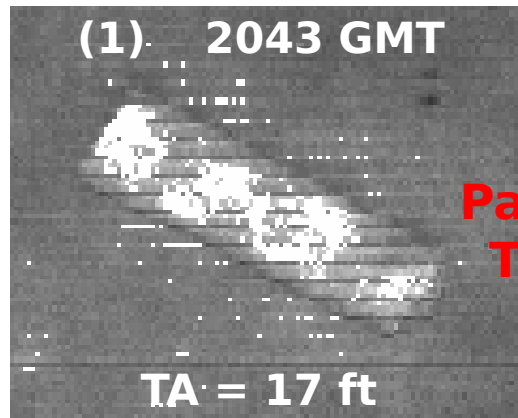
tal: \$375K



AQS-24 Snippets (4/7/11)

Step-Ups

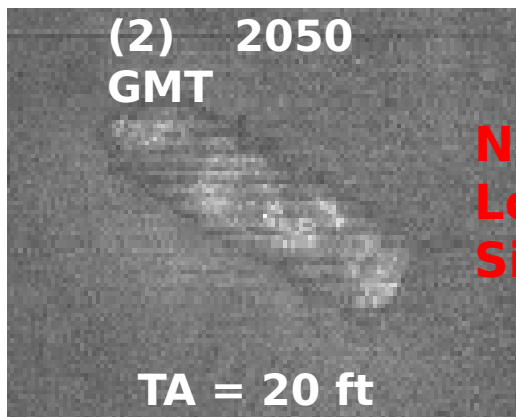
(1) 2043 GMT



TA = 17 ft

**Same Object
Passed Over Multiple
Times at Increased
Tow Heights**

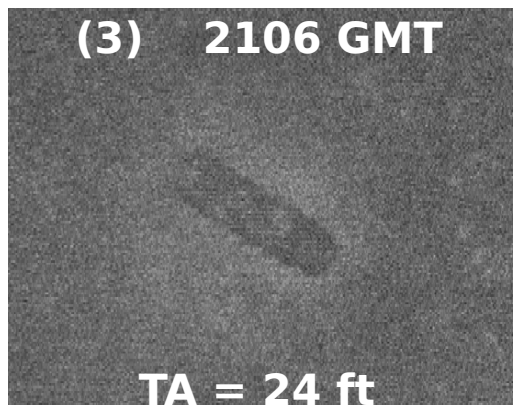
(2) 2050
GMT



TA = 20 ft

**Note:
Loss of Contrast,
Size and Detail**

(3) 2106 GMT



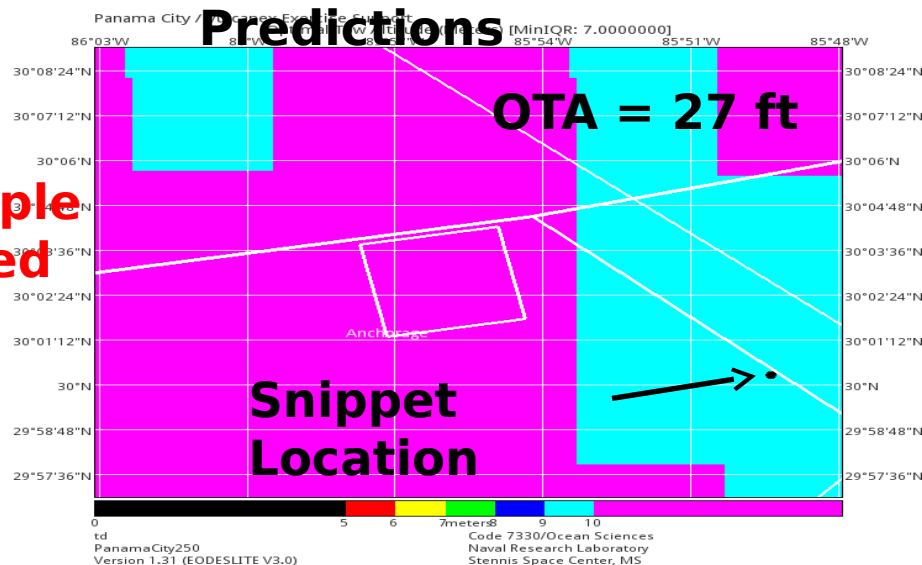
TA = 24 ft

**~20% Increase
in Predicted Tow
Heights = More
Efficient
Planning and
Clearance Times
with Same
Probability of**

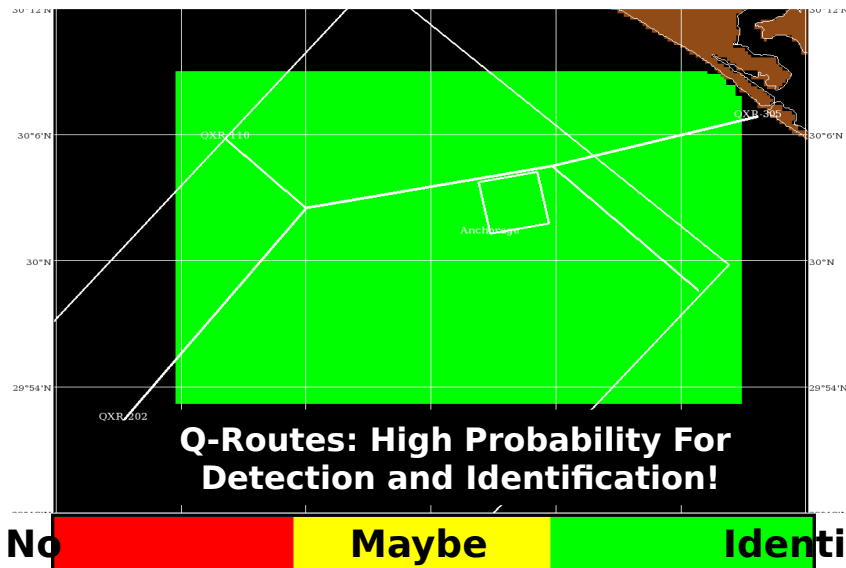
4/7/11

Performance

Predictions



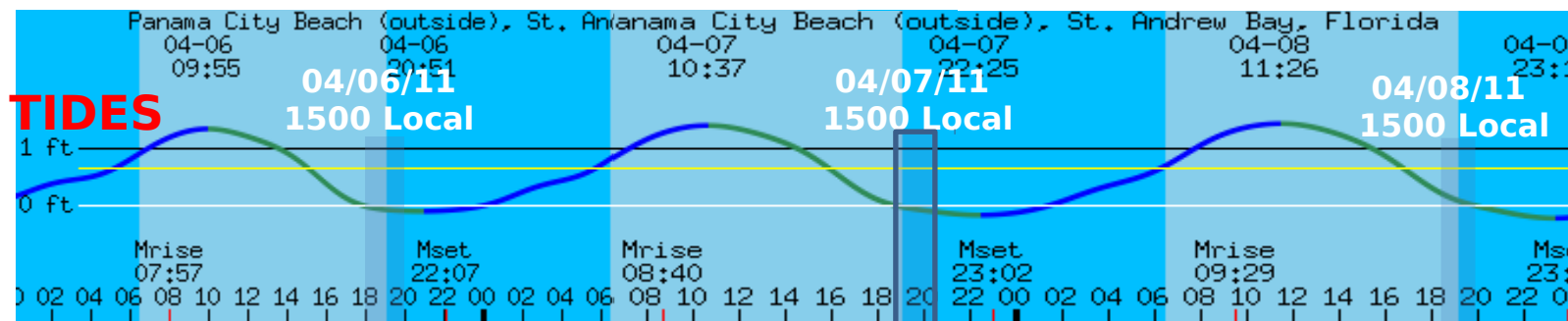
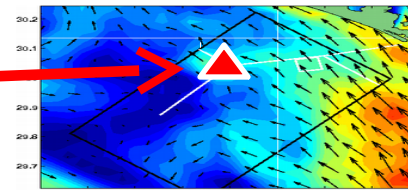
**Target Identification @ 19.7 ft Tow
Altitude**





04/06/2011

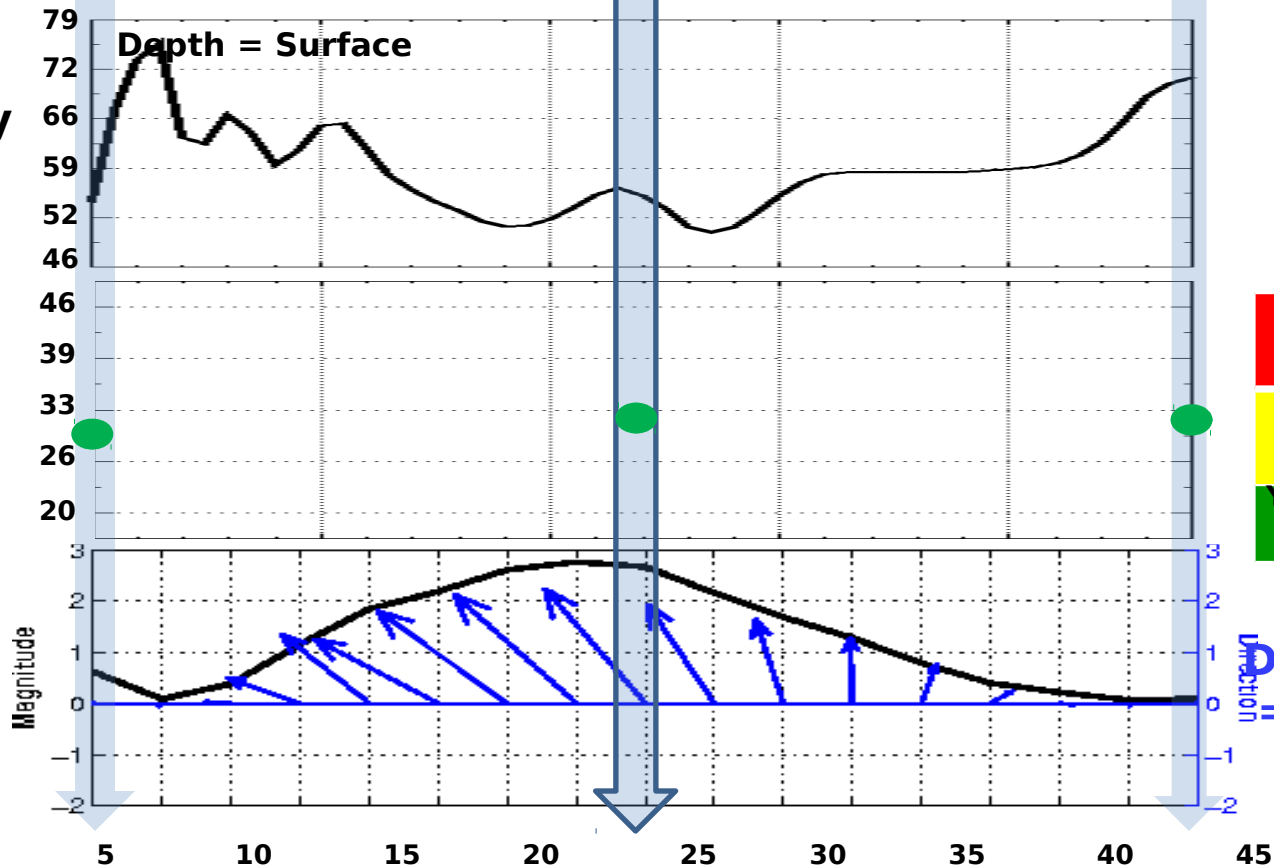
TIME SERIES @ 30.05N, 86.1W FORECAST OVER NEXT 48 HOURS



**Horizontal
Diver Visibility
Forecast
(Feet)**

**Optimal
Tow
Altitude
(Feet)**

**Modeled
Depth
Averaged
Currents
(Knots)
=Solid Line**



**No Target
ID?**

**? Color
Of
Yes Circle**

Daily Brief Summary

- 1.** Surface and subsurface turbidity (beam-c) range from 0.1-0.5 m⁻¹ in op-area for today (04/06/11 19Z), tomorrow (04/07/11) and for 48 hour forecast (04/08/11 19Z). (See Slides 2,3,4)
- 2.** Surface and subsurface diver visibility (horizontal) range from 29-100+ feet in op-area for today (04/06/11 19Z), tomorrow (04/07/11 19Z) and for 48 hour forecast (04/08/11 19Z). (See Slides 2,3,4)
- 3.** Sytem Performance: Today (04/06/11 19Z), tomorrow (04/07/11 19Z) and 48 Hour Forecast (04/08/11 19Z) expect ID and Detection over 100% in Q-Routes.
- 4.** Today (04/06/11 19Z), tomorrow (04/07/11 19Z) and 48 hour forecast (04/08/11 19Z) predicted tow heights range from 29-36 feet in Q-Routes. (See Slides 2,3,4)
- 5.** Time Series at Surface for Location 30.05N and 86.1W:
Horizontal Diver Visibility ranges from 50 to 70 feet during period starting 04/06/11 19Z to 4/8/11 19Z. Optimal Tow Height is ~30 feet during same 48 hour period yielding high probability of target ID. Surface currents during the same 48

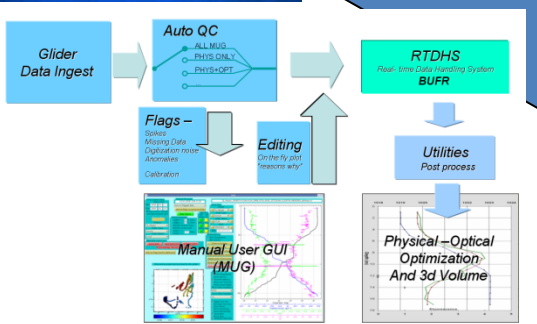
Note: Good satellite scenes collected on 3/25/11, 4/01/11, 4/03/11 & 4/6/11

Generation of the 3D Optical Volume (3DOG)

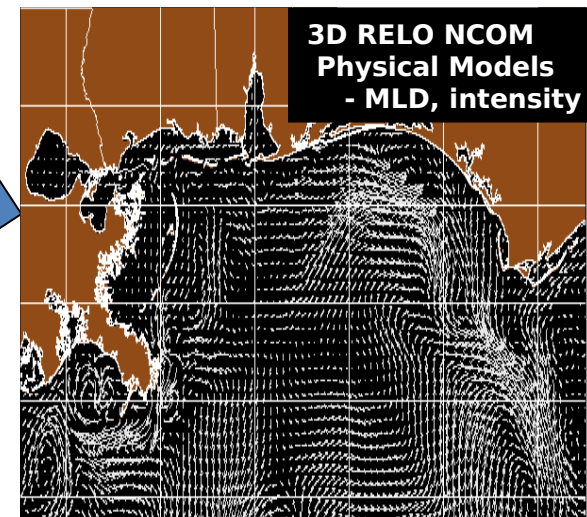
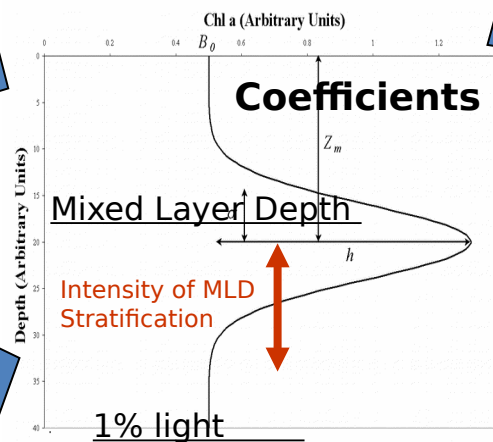


Gliders

Optics and Physics
LAGER - optics
VTR v1



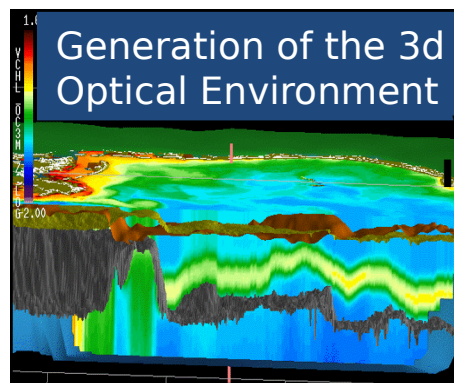
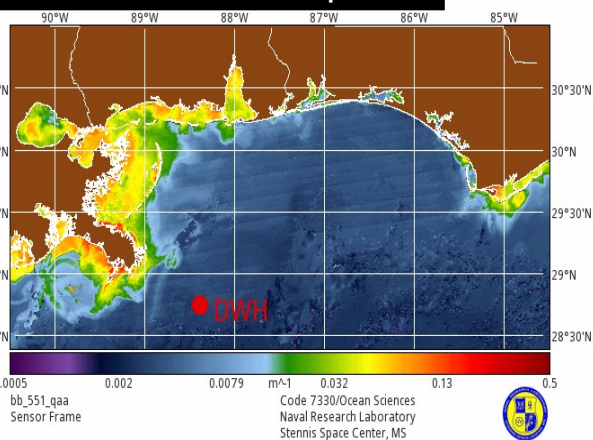
"Fusion of the data sources"
Optics (surface) to physics (subsurface)
Derived through optimization of a
Gaussian Model



Environmental Decision Aides
For Operational Planning
EOIDS (EODES)
AQS(24)

Satellite Surface Optics

9.nc



Warfighter
Information

